# Biological Evaluation of the

# Hemlock Stands at the Blue Bend Recreation Area

# Monongahela National Forest, West Virginia

Prepared by

Richard M. Turcotte
Entomologist

Adam Cumpston
Biological Science Technician

And

Katherine Gottschalk
Biological Science Technician

USDA Forest Service
Northeastern Area State and Private Forestry
Forest Health Protection
180 Canfield Street
Morgantown, WV 26505

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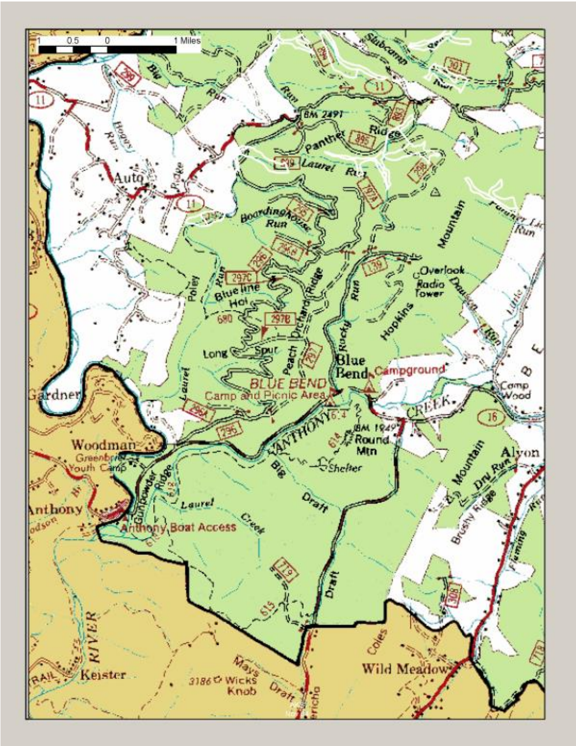
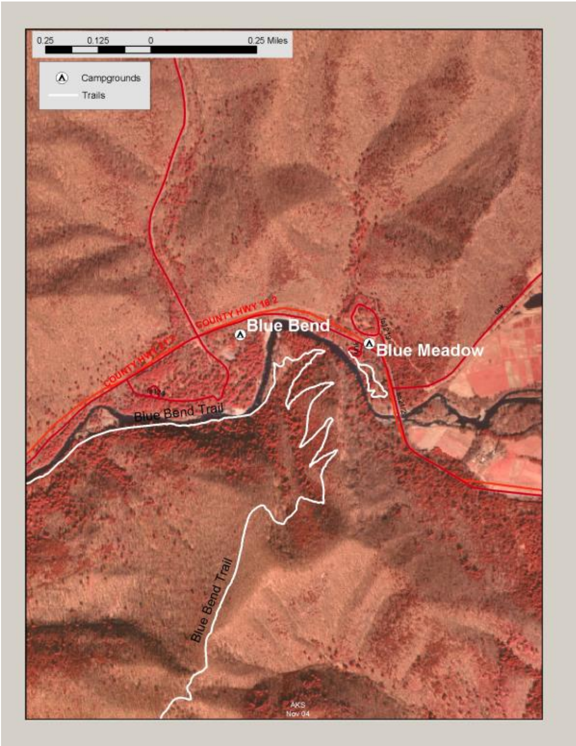
## PROJECT LOCATION/DESCRIPTION

The Blue Bend Recreation Area (BBRA) is located 12 miles northwest of White Sulphur Springs, West Virginia, on State Route 16 (figures 1 and 2). The area was constructed by the Civilian Conservation Corps in the 1930s (USDA Forest Service). It offers family recreation and solitude under the canopy of many tall hemlock trees. The BBRA encompasses about 41 acres and consists of hemlock, white pine, and mixed hardwoods. It features two camping loops: Blue Bend Campground (BBC), which has 21 campsites, and Blue Meadow Campground (BMC) with 18 sites (including four walk-in sites). Two hiking trails run through the area—the Blue Bend loop trail, which is 5 miles long, and the Anthony Creek trail, which is 3.8 miles in length.

**Figures 1 and 2. *Blue Bend and Blue Meadow Campgrounds, White Sulphur Ranger District, Monongahela National Forest.***




## PROJECT OBJECTIVES

The objectives of this biological evaluation were to 1) assess current hemlock woolly adelgid population densities within hemlock stands at the BBRA, and 2) develop treatment alternatives and recommendations to reduce and/or control the hemlock woolly adelgid.

## PROJECT METHODS

The guidelines used to evaluate current population density and impacts include[1]: 1) stand condition, 2) visual estimates of stand-level adelgid densities, 3) visual estimates of individual tree adelgid densities (based on the percentage of new growth infested with HWA[2]), and 4) visual estimates of tree condition. A 100 percent inventory of all hemlock trees (> 6" dbh) within 25 feet of accessible[3] campground units and walk-in campsites was used to provide the required information.

## PROJECT RESULTS

Hemlock woolly adelgid was found throughout the BBRA. Infestation ranged from none to heavy within the campgrounds. Current HWA populations are high enough to cause reduced growth and future mortality of infested trees.

Blue Bend Campground

One hundred hemlock trees were sampled within the 34-acre Blue Bend Campground (comp. 631, stand 7) for the presence of hemlock woolly adelgid (table 1). Fifty-seven trees had unknown HWA infestation levels, due to either a lack of new growth (preferred feeding and sampling site for HWA) or the lack of branches within a reachable height. Of these 57 trees, 28 had thinning crowns, a finding consistent with moderate to heavy HWA infestations. Of the remaining trees, 46 percent had either light or moderate levels of infestations.

Table 1. *Hemlock woolly adelgid survey results for the Blue Bend Campground, Monongahela National Forest, August 6, 2004*.

| Number of Trees | DBH Size Range (inches) | HWA Infestation level[2] |
|---|---|---|
| - | - | Heavy |
| 6 | 7-28 | Moderate |
| 14 | 6-29 | Light |
| 23 | 7-28 | None |
| 57 | 6-32 | Unknown |

Blue Meadow Campground

Thirty-six hemlock trees were sampled within the 14-acre Blue Meadow Campground (comp. 629, stand 25) for the presence of hemlock woolly adelgid (table 2). Six trees had unknown HWA infestation levels, due to either a lack of new growth or the lack of branches within a reachable height. Of these six trees, four had thinning crowns, a finding consistent with

[1] Because of restrictions on destructive sampling, Forest Health Protection staff was unable to sample trees with branches above a reachable height.
[2] Based on visual estimates from 3-5 hemlock branches: Heavy = (>50% of new growth [NG] infested), Moderate = (50% to 25% of NG infested), Light = (<25% of NG infested), None = (0% infested), Unknown = No NG present or no branches reachable.
[3] Because some campground units were in use, only the areas around open campsites were sampled.

moderate to heavy HWA infestations. Of the remaining trees, 87 percent had HWA infestations ranging from light to heavy.

Table 2. *Hemlock woolly adelgid survey results for the Blue Meadow Campground, Monongahela National Forest, August 6, 2004*.

| Number of Trees | DBH Size Range (inches) | HWA Infestation level[2] |
|---|---|---|
| 1 | 8-9 | Heavy |
| 7 | 8-14 | Moderate |
| 18 | 6-17 | Light |
| 4 | 6-10 | None |
| 6 | 6-24 | Unknown |

## MANAGEMENT ALTERNATIVES

Four management options have been evaluated for the hemlock trees at the Blue Bend Recreation Area. The intervention options were evaluated based upon the following objectives: 1) protecting hemlock resource values and 2) reducing hemlock woolly adelgid populations in infested areas. Each option is discussed below.

### Alternative 1: No Action

This alternative is considered the environmental baseline (the no action alternative). As a result, HWA populations would be allowed to increase and decrease naturally, without intervention. Because HWA has a high reproductive capacity and has demonstrated the ability to rapidly spread in recent years, it is expected that HWA populations would continue to increase throughout the BBRC and accelerate their spread to currently uninfested trees and stands within this area. Population densities will likely fluctuate periodically depending on the severity of winters, but rebound following such events, and consequently, impacts to hemlock resources throughout the BBRC would likely increase as more hemlocks succumb to this insect.

### Alternative 2: Release Predator Beetles to Establish Long-Term Population Control (Recommended Action)

This alternative involves the release of the laboratory reared predatory beetles *Sasajiscymnus tsugae*, *Laricobius nigrinus*, *Scymnus sinuanodulus*, and *Scymnus ningshanensis* in hemlock woolly adelgid-infested hemlock trees to accelerate the establishment of these predatory beetles. The proposed releases would depend on the availability of beetles. Monitoring and evaluation efforts will continue for 3 years after release to document the establishment and dispersal of the beetles and evaluate their effectiveness in reducing HWA population densities and protecting hemlock health on a stand-level basis. USDA Forest Service Forest Health Protection (FHP) entomologists will be providing a work plan with protocols to be followed for the 3-year project. USDA Forest Service FHP personnel will be responsible for conducting the releases, monitoring beetle dispersal and changes in HWA population densities, conducting tree health assessments, and reporting their results.

**Alternative 3: Systemic Insecticides (Recommended Action)**

This alternative involves the use of trunk- and soil-injected systemic insecticides to reduce hemlock woolly adelgid populations on moderately to highly infested trees. Monitoring and evaluation efforts will continue for 3 years after treatment to document the effectiveness of treatment in reducing HWA population densities and protecting hemlock health on an individual-tree basis. USDA Forest Service Forest Health Protection entomologists will be providing a work plan with protocols to be followed for the 3-year project. Additional treatments within this site are possible in the future based on monitoring results.

Several types of systemic insecticides can be injected (e.g., imidacloprid, bidrin, or Metasystox-R®) or implanted (e.g., acephate) into hemlock trees, and another (Merit®) can be applied as a soil drench or injected into the soil around hemlock trees. These insecticides are absorbed and transported by the vascular system of the tree to feeding adelgids and will effectively suppress HWA populations (McClure 1992a, Steward and Horner 1994, Evans 2000, Doccola et al. 2003, Webb et al. 2003). Of the trunk- and soil-injection systemic insecticides available, only imidacloprid marketed under the trade names Merit®, Pointer®, Imi-jet®, or Imicide® is currently labeled for soil and tree injection for the control of adelgids in forest trees.

**Alternative 4: Other HWA Control Alternatives Considered, but Dismissed**

**4.1 Ground spraying with horticultural oils, insecticidal soaps, and foliar insecticides**

These methods of treatment can be effective in situations where there is access to the trees for ground spraying equipment, including pumping trucks with high-pressure hoses, and the entire crown of each tree can be saturated with the spray (Evans 2000). Although this type of access is available for part of the BBRC, concerns about drift caused this alternative to be dismissed.

**4.2 Aerial spraying**

Aerial spraying with horticultural oils or insecticidal soaps is not an effective treatment because it fails to provide the needed "saturation" coverage of each tree crown. Aerial spraying with more toxic insecticides (e.g., malathion or diazinon) would have very significant, unacceptable impacts on a wide range of nontarget insects and other animals (Evans 2000). Therefore, this alternative was considered infeasible and was dismissed.

**4.3 Pheromone traps or other methods of disrupting reproduction**

Because HWA reproduces asexually (its populations are entirely parthenogenetic; females reproduce without males), it is not possible to disrupt reproduction through pheromone traps or other, similar methods (Evans 2000). Therefore, this alternative was considered infeasible and was dismissed.

## RECOMMENDATIONS

It is recommended that the Monongahela National Forest decide in favor of **Alternatives 2** and **3** (release and establishment of predatory beetles and soil and trunk injections of the systemic insecticide imidacloprid) in the BBRC. Host acceptance tests and choice tests have demonstrated that predatory beetles will feed on nontarget adelgid species and the possibility exists that these other adelgid and aphid species may be fed on. Imidacloprid is a systemic and contact insecticide exhibiting low to moderate mammalian toxicity, with primary activity on sucking insects. With each of these treatment options comes the potential for nontarget effects; land managers must balance the risk of these effects with the potential benefits that come with the control of the HWA. Introduction of predatory beetles is expected to reduce the impact of HWA and may provide lasting and effective control in a cost-efficient manner. Soil and trunk injections of imidacloprid are expected to reduce HWA populations on moderately to heavily infested trees and provide 1 to 2 years of protection.

## ADDITIONAL INFORMATION

### Hemlock Woolly Adelgid

Adelgids are small, soft-bodied insects that feed on plant sap. The family is divided into two genera: *Adelges* and *Pineus*. The members of this family feed exclusively on conifers. There are six species of *Adelges* that occur in North America, of which only one is native (Montgomery 1999)—the Cooley spruce gall adelgid (*Adelges cooleyi*). This adelgid occurs coast to coast in Northern North America. Its primary hosts are recorded as white (*Picea glauca*), blue (*Picea pungens*), Sitka (*Picea sitchensis*), and Engelmann (*Picea engelmannii*) spruce (Baker 1972). It has an alternate host, Douglas fir (*Pseudotsuga menziesii*). There are 10 species of *Pineus* that occur in North America, of which seven are native. Four of these (the pine bark adelgid (*Pineus strobi*), the pine leaf adelgid (*Pineus pinifoliae*), the red spruce adelgid (*Pineus floccus*), and the spruce gall adelgid (*Pineus similes*) seem to be indigenous to Eastern North America (Drooz 1989, Montgomery 1999). These species attack eastern white pine (*Pinus strobus*), red spruce (*Picea rubens*), and black spruce (*Picea mariana*) but seldom cause extensive damage (Drooz 1989, Montgomery 1999). Little is known about the population dynamics, ecological role, or the predator and parasite complex associated with these native adelgids.

Native to Japan, the hemlock woolly adelgid (*Adelges tsugae*) (HWA) is a pest of eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*T. caroliana*) (Onken et al. 1999), both of which are considered highly susceptible to the adelgid, with no documented resistance (Bentz et al. 2002). The latter tree species is found only in the southern region of the Appalachian Mountains (Onken et al. 1999). The HWA is currently established in 15 Eastern States from Georgia to Maine, and tree decline and mortality have increased at an accelerated rate since the late 1980s. For example, in the Shenandoah National Park, hemlock crown health has declined since the early 1990s. In 1990, greater than 77 percent of the hemlocks sampled were in a "healthy" condition; by 1997, less than 10 percent were in a "healthy" condition (Akerson and Hunt 1998). New Jersey has estimated a loss of 9 percent of its hemlock resource and 44 percent

remains moderately to severely impacted by HWA (Onken et al. 1999). Similar adelgid-caused impacts are also affecting most districts of the Monongahela National Forest.

The hemlock woolly adelgid is parthenogenetic (an all-female population with asexual reproduction) and has six stages of development (the egg, four nymphal instars, and the adult) and two generations a year on hemlock[4]. Each adult adelgid can produce between 50 to 300 eggs in its lifetime (McClure 1989, 1995). Although natural mortality in HWA populations is commonly between 30 and 60 percent (McClure 1989, 1996), the reproduction potential of this insect remains high. This natural mortality is generally attributed to two likely causes: 1) an extended period of cold temperatures that coincides with a susceptible period of development for the adelgid, and/or 2) a sufficient loss in the nutritional quality and quantity of the food source, which is associated with the decline in health and vigor of the host tree (McClure 1996, Onken et al. 1999). Adelgid feeding can kill a mature tree in about 5 to 7 years (McClure et al. 2001). This tiny insect (~ 1 mm) feeds on all life stages of hemlock, from seedling to mature, old-growth tree. Dispersal and movement of HWA is associated with wind, birds, deer, and other forest-dwelling mammals. Humans also move the adelgid during logging and recreational activities (McClure 1995). Natural enemies capable of maintaining low-level HWA populations are nonexistent in Eastern North America (Van Driesche et al. 1996, Wallace and Hain 1998).

HWA was first reported in the Western U.S. in the 1920s (Annand 1924, McClure 2001). HWA populations on western tree species, including western hemlock (*Tsuga heterophylla*) and mountain hemlock (*T. mertensiana*), appear to be innocuous; these tree species are believed to be resistant because little damage has been reported (McClure 2001). Unfortunately, both tree species are of limited value for hybridization and planting due to their poor adaptation to the east coast environment (Bentz et al. 2002). In the East, HWA was first reported in the 1950s near Richmond, Virginia. It was considered to be more of an urban landscape pest and was controlled using a variety of insecticides applied with ground spraying equipment. Observations of the adelgid were periodically reported in several Mid-Atlantic States in the 1960s and 1970s but it was not until the 1980s that HWA populations began to surge and spread northward to New England at an alarming rate. By the late 1980s to early 1990s, infestations of HWA were reported to be causing extensive hemlock decline and tree mortality in hemlock forests throughout the East (McClure 2001).

## Imidacloprid

Imidacloprid is a relatively new insecticide in the family of chemicals called neonicotinoids (Felsot 2001) in the chloronicotinyl subgroup (USDA Animal and Plant Health Inspection Service 2002). It has a mode of action similar to that of the botanical product nicotine, functioning as a fast-acting insect neurotoxicant (Schroeder and Flattum 1984) that binds to the nicotinergic receptor sites in the postsynaptic membrane of the insect nerve (USDA Animal and Plant Health Inspection Service 2002), mimicking the action of acetylcholine, and thereby heightening, then blocking, the firing of the postsynaptic receptors with increasing doses

[4] The hemlock woolly adelgid also has a winged form that is produced by the overwintering generation. This form must complete part of its life cycle on spruce. The apparent lack of a suitable spruce host for this form in Eastern North America results in a substantial loss of adelgids each year (McClure 1992b).

(Schroeder and Flattum 1984, Felsot 2001). Because imidacloprid is slowly degraded in the insect, it causes substantial disorder within the nervous system, leading in most cases to death (Mullins 1993, Smith and Krischik 1999).

Imidacloprid is considered to have low to moderate mammalian toxicity[5] (Mullins 1993). Chronic (repeated dose) toxicity studies have demonstrated that imidacloprid is neither carcinogenic nor mutagenic and demonstrates no primary reproductive toxicity (Mullins 1993). In studies of metabolic fate in rats, imidacloprid was rapidly absorbed and eliminated in the excreta (90 percent of the dose within 24 hours) with little bioaccumulation (0.5 percent of the dose after 48 hours) and no biologically significant differences occurring between sexes, dose level, and route of administration (USDA Animal and Plant Health Inspection Service 2002). Imidacloprid is an insecticide exhibiting both systemic and contact activity. The spectrum of activity primarily includes sucking insects (aphids, whiteflies, leaf and plant hoppers, thrips, plant bugs, and scales); many Coleopteran species; and selected species of Diptera and Lepidoptera. Activity has also been demonstrated for ants (Hymenoptera); termites (Isoptera); and cockroaches, grasshoppers, and crickets (Orthoptera). No activity has been demonstrated against nematodes or spider mites (Mullins 1993). In spider mites, imidacloprid has been demonstrated to cause an egg-laying enhancement (James and Price 2002). Since spider mites can be a problem in hemlock, any imidacloprid-treated tree should be carefully monitored for increases in mite populations.

[5] Largely because it does not bind nerve receptors in mammals sufficiently to trigger nervous activity (Felsot 2001). The selective toxicity of imidacloprid is perhaps best illustrated by its use in flea treatments approved for cats and dogs. Advantage® is applied directly to the animal's skin; this preparation carries very little, if any, risk to the animal or to the people, including children, who may handle the animal (USDA Animal and Plant Health Inspection Service 2002).

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